IJIREEICE

ISSN (Online) 2321-2004
ISSN (Print) 2321-5526

International Journal of Innovative Research in
Electrical, Electronics, Instrumentation and Control Engineering
ISO 3297:2007 Certified
Vol. 6, Issue 6, June 2018

Power Substation Protection from Lightening Over voltages and Power Surges

Prof. Vikramsingh R. Parihar[1*], Snehal Warudkar[2]

Assistant Professor, Department of Electrical Engineering, PRMCEAM, Badnera-Amravati, India[1]

U.G. Student, Department of Electrical Engineering, PRMCEAM, Badnera-Amravati, India[2]

Abstract: The protection of power substations against lightning over voltages is important for the reliable operation of the electrical network, since region surges often are chargeable for serious damages of apparatus, leading to power provide interruptions. Studies on the lightning performance of substations are necessary so as to calculate the expected over voltages and take the suitable measures. To the present direction, during this paper analyses for the lightning overvoltage performance of HV/MV substations are performed, considering varied factors, like the grounding resistance, the installation position of surge arresters and also the length of the underground cables. Main novelty of this work is that the outcomes of the lightning performance study are bestowed on an individual basis for each direct lightning hits and back flashover, whereas the analyses take into consideration not solely the grounding resistance (which is that the common observe in similar studies) however additionally the cable and also the installation position of surge arresters. The obtained results may be helpful for engineers and power utilities for the advance of the lightning performance of already existed substations or for the simpler style of recent ones.

Keywords: transmission line, power substation protection, surge arresters, lightening protection

I. INTRODUCTION

The protection of High-Voltage/Medium-Voltage (HV/MV) substations against region over voltages and also the improvement of their lightning performance are technical problems with nice importance, since they're associated with safe, uninterrupted and top quality power provide. HV/MV substations are important elements of the electric power system being the border between transmission and distribution system. The fundamental elements of a typical station are the facility transformers, the incoming overhead transmission lines, the cables, the circuit breakers, this transformers, the disconnect switches and also the ground switches. External over voltages will cause many damages to a station, resulting in insulation breakdowns, a series of malfunctions, power interruptions and issues of safety to the personnel [1-3]. What is more, lightning surges might also cause dangerous magnetic force interference issues to low voltage systems and particularly to electronic devices [4, 5]. Hence, the study of the lightning repercussions and also the style of AN acceptable lighting protection system for substations may be a crucial issue, considering the complexness of these installations and their high investment price. The adoption of the suitable protection measures per the fundamental tips of the International commonplace [3] will contribute to the limitation of the developed over voltages and also the reduction of the expected lightning faults. The planning of a lightning protection system must take into thought the random nature of the external over voltages phenomena and also the varied techno economic factors and restrictions of a station.

The position of the lightning hit, the geometrical characteristics of the external lightning protection system, the grounding resistance and also the Basic Insulation Level (BIL) are parameters that have an effect on the intensity of the lightning impact. Additionally, the installation or not of surge arresters at varied positions of the substations contains a decisive impact on the magnitude of the developed over voltages and, consequently, the expected outage rate [6, 7]. The protection of substations against the harmful effects of lightning is also achieved by victimisation highest insulation levels, taking under consideration the monetary price, or by putting in overhead ground wires so as to intercept the lightning flashes [8-10]. The implementation of metal compound gapless surge arresters can even contribute to the advance of the lightning performance of the installation, particularly in regions with high soil electric resistance [11, 12]. Moreover, the incoming surges from the connected overhead transmission lines have to be compelled to be thought of. Considering that AN external lightning protection system (overhead ground wires) combined with the action of low values of substation’s grounding resistance supply AN adequate protection against direct lightning hits, the incoming surges consists the most danger for the insulation of the installation. For this reason, the tower footing resistance contains a key role for the lightning performance of the station. In the current work, over voltages at completely different positions of a HV/MV station are calculated, considering the role of the tower footing grounding, the length of the cable and also the installation position of the arresters. The bestowed analyses concern lightning hits on the section conductors and on the overhead ground wires of the connected transmission lines,

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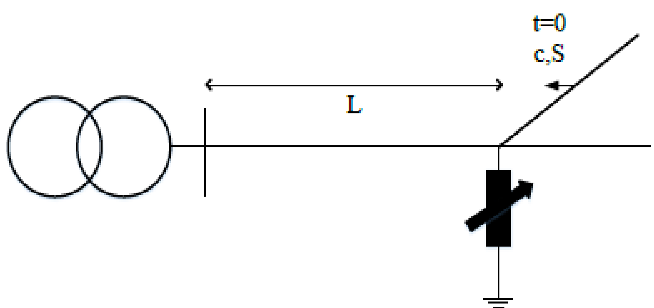
Vol. 6, Issue 6, June 2018

considering that the external Lightning Protection System (LPS) of the station protects adequately the station against direct lightning hits. Compared with different similar studies, this work reveals the necessary role of the length of the cable and examines completely different situations for the location of the arresters. Scope of this paper is to focus on that the lightning performance of the substations depends on varied factors, except the grounding resistance.

II. LIGHTNING PROTECTION OF SUBSTATIONS

Lightning surges stress the insulation of the instrumentality and should lead to tripping of the protecting devices, destruction of important elements of the station and a general destabilization of the system. A risk management assessment must be performed so as to predict the doable dangers and install the suitable instrumentality restraining the lightning effects. A four-step procedure is usually recommended in [1] to intercept the lightning flashes evaluating the importance and also the price of the beneath protection installation, work the keraunik level and also the exposure of the station, coming up with the lightning protection system per AN acceptable technique and evaluating the effectiveness and also the price of the lightning protection system (LPS). The foremost wide used ways for the planning of an efficient external LPS are the fastened angles technique, the empirical curves technique and also the electro-geometrical model [1, 3]. What is more, the lightning performance of a station may be improved by putting in surge arresters at important positions of the system. The installation position of the arresters plays necessary role, as a result of the very fact that over voltages behave as move waves. Fig. 1(a) depicts AN overvoltage running towards a electrical device, forward a propagation rate up to the speed of the sunshine. The arrester hook presents a perfect behaviour, limiting the required residual voltage. Fig. 1(b) presents the over voltages at the terminal ends of the arrester hook and also the electrical device. It should be mentioned that a voltage wave is completely mirrored once reaching AN unterminated finish of a line. The voltage level at each instant and at each purpose on the road results from the add of the various instant values of every individual voltage wave, considering the refractions and reflections as a result of the changes of the surge electrical resistance.

A connected electrical device behaves as AN unterminated finish, since its winding inductivity for quick voltage waveforms presents a lot of higher electrical resistance compared with the electrical resistance of the road. Thus, at the terminated finish this price are doubled. This analysis highlights the importance of the installation position of the arrester hook, action the very fact that the residual voltage across the arrester hook terminals might considerably vary from the developed voltage at the doorway of the electrical device. The effective protection offered by AN fittingly designed LPS needs additionally the action of low grounding resistance values. a correct station grounding system provides a path that diverts the fault currents to earth, while not prodigious the material stands up to of the equipment; at the same time, grounding system protects personnel against the hazards of electrical shock beneath fault conditions [1, 3]. Basic a part of the grounding system is that the ground grid, consisted of conductors and rods. Additionally, the grounding system includes all of the interconnected grounding facilities within the station space, together with the bottom grid, overhead ground wires, neutral conductors, underground cables, etc. [1]. In general, the grounding resistance of HV stations is sometimes terribly low (lower than 1Ω) so as to confirm low bit and step potentials within the substation. However, the tower grounding resistance of the connected overhead transmission lines varies, leading to the event of dangerous incoming surges.



(a)

Fig. 1 (a) Power electrical device protected by a surge arrester hook

IJIREEICE

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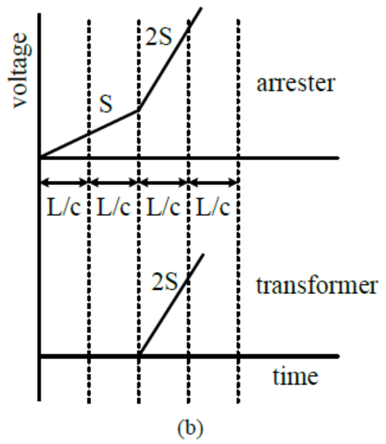

Fig. 1 (b) Developed over voltages at the terminals of the arrester hook and also the electrical device

III. SYSTEM CONFIGURATION

In general, the substations are adequately protected against direct lightning hits, per the methodologies and also the electro-geometrical models, bestowed in section two. Consequently, lightning surges that run into the overhead transmission lines that are connected with the substations are the most reason behind overvoltage stresses of the insulation of the substations' instrumentality. Just in case that lightning hits directly the section conductors of the transmission lines, 2 move waves seem the magnitude of that depends on the lightning peak current and also the surge electrical resistance of the conductors. The overvoltage wave can hit the doorway of the station and might lead to many serious damages of the parts of the substations. it's price mentioning, that the developed overvoltage isn't influenced by the tower footing resistance and also the distinctive protecting live is that the installation of surge arresters. Moreover, the position of the lightning hit, the length of the cable, the characteristics of the enforced surge arresters, the position of the installation of the arresters and also the grounding resistance of the arresters are important factors that verify the potency of the lightning protection system and have an effect on the lightning performance of the station. If a surge arrester hook is put in between section and earth of a line, a part of the lightning current are pleased to the grounding system (Fig. 3), counting on the achieved grounding resistance. The low values of the grounding resistance make sure that nearly the overall current can experience the arrester hook and also the developed overvoltage won't exceed the insulation level of the system. This analysis is performed for the configuration of Fig. 2.

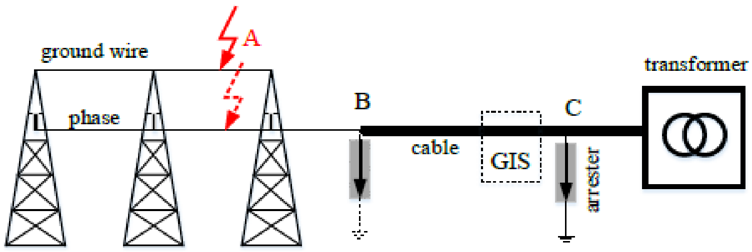

Fig. 2 System configuration

A lightning of 35 KA hits a section conductor of a one hundred fifty potential unit overhead line. The developed voltage surge travels through the conductor and also the cable to the substation's electrical device (150/20 kV). The developed over voltages at the start (position B) and also the finish (position D) of the cable are calculable, by using acceptable simulation tool. The tower footing resistance has no influence on the expected over voltages. As so much because the length of the cable (BD) issues the obtained results show that longer cables lead to the reduction of the developed over voltages. What is more, the installation position of the arresters is of nice importance for the suitable lightning performance of the station. The rise of the space between the arrester hook and also the electrical device reduces the effectiveness of the put in arresters, during a means that the overvoltage might exceed the BIL, counting on the opposite parameters, i.e., the magnitude of the surge, the grounding resistance and also the length of the cable.

Especially, in case of cables with length but a thousand m the matter is additional intense, since the initial surge is higher and a non-appropriately put in arrester hook won't shield the instrumentality. For this reason, the protection distance of the arresters must be taken into thought throughout the initial style of the installation and also the choice of the characteristics of the arresters.

Over voltages in case of indirect lightning hit

When a lightning hits the bottom wire or the tower of AN overhead line, the magnitude of the developed overvoltage depends on the tower footing resistance, the induction of the tower and also the rise time of the injected lightning current (Fig. 3). If the overvoltage exceeds the insulation level of the road, a back flashover is occurred. The ensuing surge propagates to the connected station and might cause serious malfunctions of the system. Back flashover at the connected transmission lines may be a common reason of substations' instrumentality faults and damages.

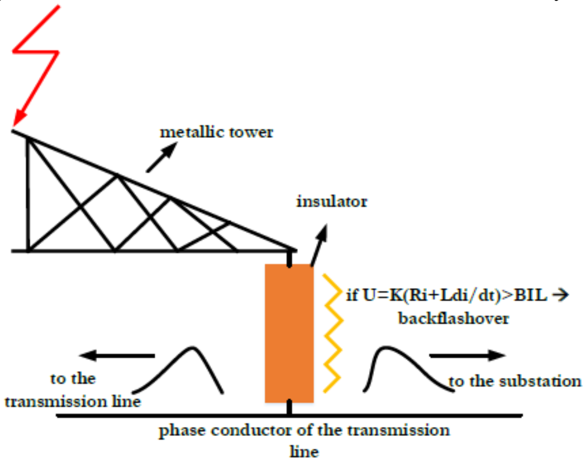

Fig. 3 Lightning hit on the bronze tower of AN overhead line

The lightning performance of the system may be improved by putting in surge arresters in parallel with the insulators and at the first facet of the electrical device (Fig. 4). Surge arresters divert this of the lightning strike to earth and restrain the BIL. The installation of metal compound gapless surge arresters is important, otherwise the incoming voltage waves can stress the insulation of the instrumentality, leading to faults and interruption of the traditional operation of the station. A lightning of two hundred Ka hits the grounding wire of a one hundred fifty potential unit overhead line.

If the arising voltage exceeds the fundamental insulation level (750 kV) then a back flashover happens [14, 15]. The developed voltage surges travel through the conductor and also the cable to the substation's electrical device (150/20 kV). The developed over voltages at the start (position B) and also the finish (position D) of the cable are calculable, by victimisation acceptable simulation tool. It's price mentioning that the chosen level of the injected lightning current is extraordinarily higher compared to the thought of one just in case of direct hit, since per the applied electro-geometrical model, high currents strike the towers or the overhead ground wires and low currents hit the section conductors. A lightning current of two hundred Ka peak might produce AN overvoltage higher than the outlined limit, influenced by the grounding resistance, the insulators and also the implementation (or not) of arresters.

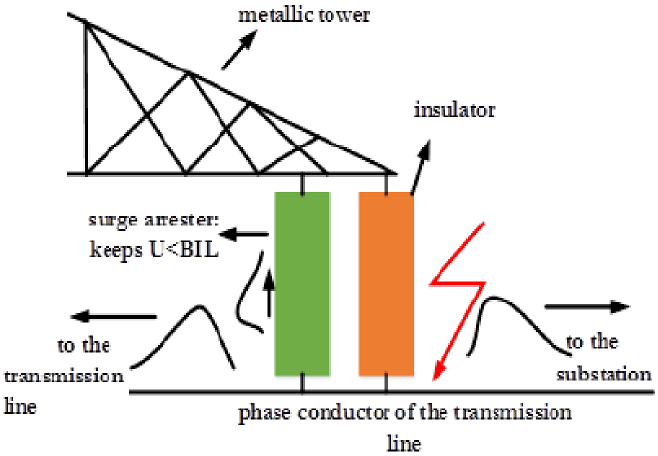

Fig. 4 Overhead line protected by surge arresters

The action of low grounding resistance values may be a decisive parameter, so as to confirm the adequate lightning protection of the station. Surge arresters cannot supply the demanded protection level, if the grounding system isn't acceptable. Consequently, the installation of surge arresters cannot continuously warrant the reduction of the expected over voltages. The potency of the surge arresters is additionally strengthened by the length of the cable. The

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calculations show that the calculable over voltages are powerfully captivated with the space (BD). Additionally, the installation position of the arresters is of nice importance, relating to the protecting distance.

• The developed over voltages are powerfully captivated with the length of the cable. Long cables present a much better lightning performance.
• Tower footing resistance has no influence on the expected over voltages.
• The arresters ought to be put in close to electrical device, otherwise the voltage at the instrumentality to be protected are significantly on top of the residual voltage at the terminals of the arrester hook.

The case of a lightning that hits on the tower or the bottom wires of the connected line is taken into account a significant threat for the protection and also the traditional operation of the substations. the suitable protection against back flashover phenomena needs the data of the expected surges, so as to style the lightning protection configuration and choose the electrical characteristics of the protecting suggests that. To the present direction, the performed analyses highlight varied aspects that the designers ought to take under consideration throughout the initial study of the lightning protection system of the station, such as:
• Low values of tower footinig resistance continuously improve the lightning performance of the line; low tower footing resistances don't permit the potential of the tower to exceed the BIL and prevents back flashover.
• Long cable lengths contribute to the reduction of the expected over voltages. Especially, just in case that the tower footing resistance can't be improved, the rise of the cable will balance the negative effects of the inadequate grounding system.
• The protecting distance of the put in arresters depends on the slope of the incoming surge and also the nominal protection level of the device. The installation of the arresters distant from the instrumentality to be protected reduces their potency, leading to the event of great over voltages on top of the nominal residual voltage of the arresters.

IV. CONCLUSION

The paper presents studies on the lightning overvoltage performance of HV/MV substations so as to contribute in their simpler lightning protection. Additionally, to the grounding resistance that previous studies take into thought, this work considers additionally different necessary factors like the installation position of surge arresters and also the length of the underground cables. it's tested that each of these factors influence considerably the lightning performance of HV/MV substations. what is more each direct lightning hits and back flashover development are thought of within the studies. The obtained results may be terribly helpful to engineers and power utilities for the advance of the lightning performance of already existed HV/MV substations or for the simpler style of recent ones.

REFERENCES

[1] Vikramsingh R. Parihar, UPFC based distance relays for protection of transmission systems employing FACTS, International Journal of Advanced Engineering and Technology (IJAET), Volume 2, Issue 2, pp 4-7, May 2018
[2] Vikramsingh R. Parihar, Automatic Fault Detection in Transmission Lines using GSM Technology, International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering (IJIREEICE), Volume 6, Issue 4, pp 90-95, April 2018
[3] Vikramsingh R. Parihar, Line Trap and Artificial Intelligence Based Double Circuit Transmission Line Fault Classification, IEEE International Conference on Energy, Communication, Data Analytics and Soft Computing (ICECDS 2017).
[4] Vikramsingh R. Parihar, Graph Theory Based Approach For Image Segmentation Using Wavelet Transform, International Journal of Image Processing (IJIP), Volume 8, Issue 5, pp 255-277, Sept 2014
[5] Vikramsingh R. Parihar, Heartbeat and Temperature Monitoring System for Remote Patients using Arduino, International Journal of Advanced Engineering Research and Science (IJAERS), Volume 4, Issue 5, PP 55-58, May 2017
[6] Vikramsingh R. Parihar, PC Controlled Electrical Line Cutting System, International Journal of Engineering Science and Computing (IJESC), Volume 7, Issue 5, pp 11380-11381, May 2017
[7] Vikramsingh R. Parihar, Overview and an Approach to Develop a Four Quadrant Control System for DC Motors without using Microcontroller, International Journal of Engineering Science and Computing (IJESC), Volume 7, Issue 5, pp 11879-11881, May 2017
[8] Vikramsingh R. Parihar, Image Analysis and Image Mining Techniques: A Review, Journal of Image Processing and Artificial Intelligence (MAT Journals), June 2017
[9] Vikramsingh R. Parihar, Power Transformer Protection using Fuzzy Logic based Controller, International Journal of Engineering Research (IJER), Volume 6, Issue 7, pp 366-370, July 2017
[10] Vikramsingh R. Parihar, Overview and an Approach to Real Time Face Detection and Recognition, International Advanced Research Journal in Science, Engineering and Technology (IARJSET), Volume 4, Issue 9, PP 39-46, Sept 2017
[11] "Vikramsingh R. Parihar, Neural Network and Fuzzy Logic Based Controller For Transformer Protection, International Journal of Current Engineering and Scientific Research (IJCESR), Volume 4, Issue 9, PP 33-38 , Sept 2017"
[12] Vikramsingh R. Parihar, A Novel Approach to Power Transformer Fault Protection using Artificial Neural Network, International Journal of Current Engineering and Scientific Research (IJCESR), Volume 4, Issue 9, PP 33-38 , Sept 2017
[13] Vikramsingh R. Parihar, Power Transformer Fault Protection using Artificial Neural Network, Journal of Electrical and Power System Engineering (MAT Journals), Volume 3, Issue 3, pp 1-5 , Sept 2017
[14] Vikramsingh R. Parihar, Fuzzy Logic based Controller for Power Transformer Protection, Journal of Electrical and Power System Engineering (MAT Journals), Volume 3, Issue 3, pp 1-5 , Oct 2017

IJIREEICE

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ISSN (Print) 2321-5526

International Journal of Innovative Research in
Electrical, Electronics, Instrumentation and Control Engineering
ISO 3297:2007 Certified
Vol. 6, Issue 6, June 2018

[15] Vikramsingh R. Parihar, Real Time Face Detection and Recognition: Overview and Suggested Approach, Journal of Image Processing and Artificial Intelligence (MAT Journals), Volume 3, Issue 3, pp 1-6, Sept 2017
[16] Vikramsingh R. Parihar, A Novel Approach to Real Time Face Detection and Recognition, International Journal of Computer Sciences and Engineering (IJCSE), Volume 5, Issue 9, pp 62-67, Sept 2017
[17] Vikramsingh R. Parihar, Automatic Irrigation System Using Android Mobile: A Review, International Journal of Advanced Research in Computer and Communication Engineering (IJARCCE), Volume 6, Issue 9, pp 200-203, Oct 2017
[18] Vikramsingh R. Parihar, Transmission Line Multiple Fault Detection: A Review and an Approach, International Journal of Current Engineering and Scientific Research (IJCESR), Volume 4, Issue 10 pp 1-7, Oct 2017
[19] "Vikramsingh R. Parihar, Regenerative Braking System for Energy Harvesting from Railways and Vehicles: A Review and an Approach, International Journal of Innovative Research in Electrical, Electronics, Instrumentation and Control Engineering (IJIREEICE), Volume 5, Issue 10, pp 18-25, Oct 2017"
[20] Vikramsingh R. Parihar, RFID Based Student Attendance Management System: A Review and an Approach, International Advanced Research Journal in Science, Engineering and Technology (IARJSET), Volume 4, Issue 9, pp 262-265, Sept 2017
[21] Vikramsingh R. Parihar, Distance Protection Problem in Series-Compensated Transmission Lines, International Journal of Advanced Trends in Technology, Management and Applied Science (IJATTMAS), Volume 3, Issue 10, pp 44-48, Oct 2017
[22] "Vikramsingh R. Parihar, Series-Compensated Transmission Line Problem in Distance Protection, International Journal of Electrical, Electronics and Communication Engineering (IJEECE), Volume 3, Issue 10, pp 1-9, Oct 2017"
[23] Vikramsingh R. Parihar, Series Compensated Line Protection using Artificial Neural Network, International Advanced Research Journal in Science, Engineering and Technology (IARJSET), Volume 4, Issue 10, pp 102-111, Oct 2017
[24] Vikramsingh R. Parihar, Protection Scheme of Fault Detection in High Voltage Transmission Line, International Journal of Advanced Trends in Technology, Management and Applied Science (IJATTMAS), Volume 3, Issue 11, pp 1-4, Nov 2017
[25] Vikramsingh R. Parihar, IOT Based Communication Technology for High Voltage Transmission System, Journal of Electrical and Power System Engineering (MAT Journals), Volume 3, Issue 3, pp 1-6 , Nov 2017
[26] Vikramsingh R. Parihar,Industrial Control System Cyber Security: Review & Recommendations, Journal of Network Security Computer Networks (MAT Journals), Volume 3, Issue 3, pp 1-9 , Dec 2017
[27] Vikramsingh R. Parihar, Control System Security: An Issue, Journal of Control System and Control Instrumentation (MAT Journals), Volume 3, Issue 3, pp 1-5 , Dec 2017
[28] Vikramsingh R. Parihar, Resilient Designs of Control Systems Analysis and Review, Journal of Control System and Control Instrumentation (MAT Journals), Volume 3, Issue 3, pp 1-9 , Dec 2017

BIOGRAPHY

Prof. Vikramsingh R. Parihar is an Assistant Professor in Electrical Department, PRMCEAM, Badnera-Amravati having 6 years of experience. He has received the B.E degree in Instrumentation from SantGadge Baba Amravati University, India, in 2011 and the M.E degree in Electrical and Electronics Engineering, SantGadge Baba Amravati University, India, in 2014. He is editorial board member of 19 recognized journals and life member of ISTE, HKSME, ICSES, IJCSE, theIRED Engineering New Zealand and IAENG. His domain of research includes Electrical Engineering, Instrumentation, Electrical Power Systems, Electrical and Electronics Engineering, Digital Image Processing, Neuro Fuzzy Systems and has contributed to research in a commendable way by publishing 36 research papers in National/International Journals and 4 papers in IEEE Conferences.